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THE IMPACT OF SCENARIO-BASED LEARNING ON THE SCIENTIFIC CREATIVITY AND REFLECTIVE THINKING SKILLS OF FOURTH-GRADE STUDENTS IN PRIMARY SCHOOL

Tekin Guler

Abstract. *The current study examines the impacts of scenario-based science activities on the scientific creativity and reflective thinking skills of fourth-grade students in primary school. Therefore, it was carried out in a primary school in Yozgat city center during the 2023-2024 Academic Year. An experimental group (24 students [13 girls, 11 boys]) and a control group (22 students [12 girls, 10 boys]) were formed from the fourth grade of the school in question. Science Scientific Creativity Questionnaire and Science Reflective Thinking Scale were utilized as data collection tools during the experimental process, which lasted ten weeks with three hours each week. The data obtained via the research were analyzed through independent samples t-tests along with dependent samples t-tests. The results obtained through the analysis exhibited a significant difference in the experimental group's favor with regard to understanding, reflection, and total score of reflective thinking in all sub-dimensions of scientific creativity. Based on these results, it is thought that using scenario-based learning activities would be beneficial in primary school science courses.*

Keywords: *primary school, reflective thinking, science education, scientific creativity*

Tekin Guler
Yozgat Bozok University, Türkiye

Introduction

Nowadays, the concept of science literacy has gained increasing importance in parallel with the changes in science and technology. Science literacy aims to develop the questioning, problem-solving, and decision-making skills of students and to enable them with the attitudes, knowledge, and skills required for lifelong learning (Roberts, 2007). Moreover, scientific literacy involves making decisions, using scientific knowledge, and drawing evidence-based conclusions in the process of interpreting the world and the changes made by people in this world (The Organization for Economic Cooperation and Development [OECD], 2006). Based on its increasing significance and the changes in science and technology, the concept of science literacy has entered into a process of evolution from Vision I to Vision III (Guler, 2024c; Roberts, 2007). Vision I highlights the product and process dimensions of science and focuses on teaching scientific knowledge, processes, and the relationships between them. Hence, students are expected to use the scientific concepts they learn in order to solve the individual, social, and cultural problems they encounter in their daily lives (Bybee, 2015; Guler, 2024c). On the other hand, in Vision II, the emphasis is first on creating contexts and then accessing scientific knowledge and processes so as to improve the decision-making skills of students on science-related issues (Guler, 2024c; Roberts, 2007). Vision III, therefore, stresses sustainability and value in science literacy, based on the prediction that society needs educated and critical-thinking individuals who can make science and value-based decisions about sustainability issues (Hodson, 2011; Sjöström, 2015). Next Generation Science Standards [NGSS] (2013) bears traces of these three visions of science literacy in terms of its applications and adoption of an interdisciplinary approach, which prioritizes scientific processes, connects with social and cultural problems, and emphasizes scientific communication and decision-making. A similar situation to this emphasis in NGSS (2013) is also included in the 2018 science

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curriculum in Türkiye, which bears traces of science literacy visions with the field of Knowledge, Skills, Sense and Science Technology-Society-Environment learning (Saglam et al., 2016). Briefly, this curriculum can be claimed to have a structure that synthesizes different visions of science literacy and to envisage specifically the use of teaching methods and techniques which enable students to participate in the process of learning actively, support thinking skills, and provide meaningful and permanent learning (Guler, 2024a; Guler, 2024c). One of the methods thought to be effective in gaining these competencies, which are necessary for reaching science literacy, is scenario-based learning. Scenario-based learning is an innovative education method which aims to equip students with knowledge and skills in a real-world context (Mariappan et al., 2004). This learning approach allows students to understand theoretical knowledge more profoundly by applying it in practice. Scenarios generally include situations where students are provided various problems, situations, or events and are expected to generate solutions in this context (Bayrak, 2010; Guler, 2024b; Mariappan et al., 2004). The success of scenario-based learning is dependent on designing scenarios which are realistic and appropriate to the level of students (Guler, 2024b). In this regard, well-designed scenarios enable students an opportunity to question their knowledge, acquire new information, and use this information in practice. In this way, students acquire not only theoretical knowledge but also learn how to utilize this knowledge (Cerrah-Ozsevgec & Kocadag, 2013). Scenario-based learning not only triggers the student to participate in the process actively but ensures that the student enjoys the process, as well (Guler, 2024b; Flynn & Klein, 2001; Razzouk, 2011). These features of scenario-based learning cause the use of this method at the primary school level to become more important. As children at the primary school level have difficulty in learning abstract subjects as a characteristic of their age and have difficulty in transferring the learned subjects into life (e.g., Akar & Yadigaroğlu, 2021), they get bored with the learning process quickly. Furthermore, in this period when attitudes towards science begin to form, loving science and feeling that being interested in science becomes enjoyable, affects the future lives of children directly. In this respect, it is a known fact that scenario-based learning influences attitudes toward science positively (Karaoglan, 2019; Kemiksiz, 2016; Ozturk & Karakas, 2023; Razzouk, 2011). In addition to these advantages of scenario-based learning, studies in the literature indicate that scenario-based learning affects students' academic success positively (Karaoglan, 2019; Ozkurt-Ozturk, 2019; Yıldız, 2022) and increases the permanence of what is learned (Ciraj et al., 2010; Ozkurt-Ozturk, 2019; Smith, 1987; Yıldız, 2022). In the previous literature, some studies exist, which suggest that it increases students' motivation (Karci, 2018), is effective in terms of eliminating misconceptions (Cerrah-Ozsevgec & Kocadag, 2013), and is effective in gaining scientific thinking habits (Avcı & Bayrak, 2013; Cakir & Kilcan, 2022; Siddiqui et al., 2008). When those advantages are considered, it is thought that using scenario-based learning at the primary school level will provide many advantages, such as making children love science and increasing their academic success in science classes. In spite of the advantages it will provide, limited studies on the use of scenario-based learning in primary school science teaching can be found in the literature (Karaoglan, 2019; Ozkurt-Ozturk, 2019; Yıldız, 2022). Similarly, there are limited studies on scientific creativity at the primary school level (Cremin et al., 2015; Cavusoglu, 2022; Jongluecha & Worapun, 2022) and reflective thinking (Altın & Saracaloğlu, 2018; Wendell et al., 2017), which are directly or indirectly among the 21st-century skills. These studies generally examine students' ability to present creative ideas, (Bhakti & Austiti, 2018; Cavusoglu, 2022), or aim to find out the impact of the intervention on creative thinking (Guler, 2024; Jongluecha & Worapun, 2022; McCormak, 1971), the effect of reflective thinking on decision-making processes of students (Wendell et al., 2017), and the effect of the intervention on reflective thinking (Atabas, 2020; Guler, 2024a; Kozikoglu & Tunc, 2020). These limitations in the literature on scenario-based learning, scientific creativity, and reflective thinking form the basis for the present study. This study is thought to contribute significantly to the literature by determining how the use of scenario-based learning in science classes at the primary school level influences the development of two important skills, such as scientific creativity and reflective thinking. Moreover, this study will encourage teachers to use scenario-based learning at the primary school level, and it will provide good examples for teachers to use. In this respect, this study has aimed to observe the impact of scenario-based learning on the scientific creativity and reflective thinking skills of fourth-grade students studying in a primary school. Bearing this in mind, the questions below have been intended to be answered;

1. How does the use of scenario-based learning activities in the fourth-grade primary school science course impact scientific creativity skills?
2. How does the use of scenario-based learning activities in the fourth-grade primary school science course impact reflective thinking skills?

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Research Methodology

General Background

The study employed a quasi-experimental design featuring a pre- and post-test control group. This non-randomized approach aims to control the effect of certain variables, despite not randomly assigning participants to experimental groups (Büyüköztürk, 2008). The current study was carried out with fourth-grade students in a public primary school in Yozgat, Türkiye. Two classes at the fourth-grade level in the school, possessing similar characteristics with regard to the number of students and gender distribution, were selected so as to form the experimental and control groups in the study. A simple random sampling method was utilized in order to ensure impartiality in creating the control and experimental groups (Büyüköztürk, 2008). Following the formation of groups, the scenarios that would be used in the teaching process in the experimental group were built by the researcher.

The Development of Scenarios

Within the scope of the study, scenario-based activities developed by the researcher were practiced with the students who were taking part in the experimental group. The phasing made by Harfler (1997) was utilized while creating these activities, and the process of building scenarios was as follows;

- Planning: At this stage, the fourth-grade science curriculum was examined, and all learning outcomes in the "Our Food" and "Human and Environment" units within the "Living Creatures and Life" subject area in the 2018 Science Curriculum were chosen as the scope for the scenarios to be prepared.
- Writing: At this stage, the selected topics and learning outcomes were grouped in order to create scenarios. While making this grouping, the aim was to make the scenarios appropriate for fourth-grade students and to increase active participation in the activities without getting bored throughout the process. Furthermore, care has been taken to ensure full coverage without ignoring any subject or achievement. Considering the age characteristics of fourth-grade students, it was thought that the use of fairy-tale characters would attract much attention, and in this regard, the characters in the scenario (king, queen, etc.) were created. However, scenarios were built by blending real-life situations with these fairy-tale characters due to the nature of scenario-based learning. A total of four different scenarios were built, and the scenarios were sent to three experts: a primary school teacher, a Turkish teacher, and an expert in the field of classroom education at university level, to ask for their opinions. Necessary corrections were made by taking the suggestions of experts, such as simplifying the language and shortening the script texts into account.
- Practice: The prepared scenarios were practiced with fourth-grade students studying in a primary school in the Çekerek district of Yozgat. During the practice process, the problems experienced by the teacher and the students were recorded by the primary school teacher and the researcher who was in the classroom as an observer. The records kept by the teacher were shared with the researcher at the end of each scenario.
- Correction: Following the interview with the primary school teacher after the practice and the observation made by the researcher during the practice, corrections that were deemed necessary were made including giving more clues within the problem so that the student could create a problem, reducing the number of characters in the scenario text, detailing the lesson plan for the teacher, etc. The scenarios were sent to three experts again, including a classroom teacher, a Turkish language teacher, and a Classroom Education expert at the university level, and the experts were asked for their opinions on the scenario. The process of building scenarios was finalized by implementing formal correction suggestions of the experts. An example of the scenarios utilized within the scope of the study is displayed in Figure 1.

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Picture 1
Example Scenario

Who will be The New Queen?

Once upon a time, there was a country where everyone lived in peace. The king was good to his people and tried to make their lives better. His country was facing problems. It is lovely but crowded, and has very limited energy resources.

This makes it hard to meet the country's electricity needs. People don't use electricity wisely. This meant too much electricity was used for lighting, so the country wasn't well enough lit in the evening. The king wanted to keep his people safe and healthy. He wanted the streets and avenues of his country to be brightly lit, but he also wanted to use the country's limited energy resources wisely. However, he did not want the beauty of the country and the eye health of his people to deteriorate. The sky, the stars and the moon look very beautiful in the evening and protect the eye health of the people in his country. He tried but couldn't find a way to do it. He asked his vizier to find a way to organize a contest. The winner of the contest will be the person who finds the best way to use electricity resources economically, designs the best lighting, doesn't spoil the beauty of the country and protects people's eyes. The winner also had to explain how to use the lights. The king said the winner of the competition would be his vizier. Asli and Ege, two young inventors, started planning how to win the contest.

What are the questions Aslı and Ege need to find the answers to? Write them down below.

1.question:

2. question:

3. question:

4. question:

Sample

The school where this study was carried out was selected by using the convenient sampling method, and in this respect, a public primary school located in the Yozgat province of Türkiye was preferred. Two classes with similar class sizes and similar gender distribution at the fourth-grade level in this school in the 2023-2024 academic year were chosen by using the simple random sampling method while forming both groups. Data regarding the students in groups are displayed in Table 1.

Table 1
Information About the Students in the Sample Group

Group	Grade Level	Gender		Total
		Girls	Boys	
Experimental Group	Fourth Grade	13	11	24
Control Group	Fourth Grade	12	10	22

As presented in Table 1, the experimental group is comprised of 24 students (13 Girls, 11 Boys) while the control group involves 22 students (12 Girls, 10 Boys). Even though the number of students in both groups is different, the gender distribution of the groups is similar. Moreover, placing the classes in two groups in the same school stemmed from the fact that the students could be ensured to live in similar environments and show similar socio-economic and cultural characteristics. Necessary permissions were obtained from the school where the study would be conducted, using ethics committee permission. The researcher interviewed the teacher of the class in which the study would be conducted and the students, and as a result of this interview, the teacher and students took part in the study voluntarily. Lastly, throughout the practice, all students in both groups participated in all the activities and showed no attendance problems throughout the process.

The Process and Practice

To achieve the aims of the study, four different scenarios regarding the target concepts were developed. In order to save time, these scenarios began to be practiced in the experimental group during the week following

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the development of each scenario. The model for the practice of scenario-based learning developed by Cerrah-Ozsevgec and Kocadag (2013) was utilized to practice the scenarios in the experimental group. In this model, the scenarios prepared are read by the students, and problems are created by the students depending on the scenarios read. These problems are tried to be solved by the students. If there are different or contradictory ideas regarding the solution of the problems, peer persuasion is performed. Finally, the process is evaluated together with the students. In Turkey, science lessons are included in the curriculum at the 4th-grade level of primary school for three hours a week. During the first lesson, the scenarios were read first silently and individually by the students and then read aloud by a selected student. Based on the scenario read, the students were asked to create a research problem. Similar problems were combined by discussing the problems created by the students. Students decided on the problem they wanted to solve and presented different solution methods to solve the problem. Discussions were held about solution methods, and any opposing ideas were tried to be resolved through peer persuasion. Students researched the solution they determined and presented their research results to the class with the method they chose. Following the presentations, the entire process was discussed and evaluated in the classroom. In the control group, the same topics and concepts were taught by using the activities in the textbook and smart board activities. Activities in EBA (Education Information Network), which is frequently used by classroom teachers in Turkey, were utilized in smart board activities. Data collection tools were initially performed with both groups as a pre-test, and then scenario-based learning activities were practiced in the experimental group, as mentioned above. Before the application, the teachers were provided with theoretical information by the researcher about scenario-based learning and the practice processes of the developed scenarios. Besides, the teachers working in the experimental and control groups had a master's degree and were willing to practice. After a 10-week application, three hours a week, the process was finalized by applying the data collection tools as a post-test in both groups.

Data Collection Tools

The data to achieve the aims of the current study were collected through the Science Scientific Creativity Questionnaire and the Science Reflective Thinking Scale developed by Guler (2024a).

Science Scientific Creativity Questionnaire

This questionnaire, developed by Guler (2024a), is designed specifically for the field of science for the fourth-grade level and measures all dimensions of the scientific creativity model suggested by Hu and Adey (2002) (i.e. science knowledge, science problem, science phenomena, technical product, flexibility, fluency, originality, thinking and imagination). The tasks regarding the validity and reliability of the questionnaire were carried out by Guler (2024a), and the content validity of the questionnaire, which consists of seven items, was calculated to be 100%. The Cronbach Alpha value of the questionnaire in question was calculated to be .901 (Guler, 2024a), which suggests that it has a high level of reliability since it is between .80 and 1.00 (Büyüköztürk, 2008). The questionnaire was preferred because it was specific to the field of science at the fourth grade level, and its validity and reliability studies had been performed. The scoring procedure suggested by Guler (2024a) was utilized so as to score the survey. The inter-rater reliability was observed to be 88% in the scoring performed by the three experts mentioned before.

Science Reflective Thinking Scale

This 5-point Likert scale, developed by Guler (2024a), includes the sub-dimensions of understanding, reflection, and critical reflection specific to the field of science at the fourth-grade level. The tasks regarding the scale's validity and reliability were executed by Guler (2024a), and the total variance explained by the scale's three-dimensional structure was determined to be 66.59%. The Cronbach Alpha coefficient of the entire scale was realized to be .95, and the Cronbach Alpha coefficients of the sub-dimensions (understanding, reflection, critical reflection) were .88, .93, and .89, respectively (Guler, 2024a). The fact that these values are higher than .80 for the sub-dimensions and the entire scale suggests that it is highly reliable (Büyüköztürk, 2008). Furthermore, the item-total correlation of all items in the scale is observed to be above .30, which shows that the discrimination of the items is high (Büyüköztürk, 2008).

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Data Analysis

For comparing both groups (i.e. the experimental and control group), the current study benefited from an independent samples t-test with the SPSS 21.0 Package program (see Table 2 and Table 5) as the data obtained from the Science Scientific Creativity Questionnaire and the Science Reflective Thinking Scale did not show a significant difference in the scores obtained by the groups from the pre-test. The dependent sample t-test was utilized in order to make comparison between the groups, and the analysis results are presented in tables.

When a significant difference was realized between the pre- and post-test scores while comparing the groups within themselves and with each other, the effect size (Hedge's g) was calculated. In cases where the sample size is less than 50, Hedge's g value makes a more sensitive measurement than Cohen's d (Thalheimer & Cook, 2002). The obtained Hedges' g values were interpreted by the following criteria: $g < 0.14$ "Negligible", $0.15 < g < 0.39$ "Low effect", $0.40 < g < 0.74$ "Medium effect", $0.75 < g < 1.09$ "Large effect", $1.10 < g < 1.44$ "Very large effect" and $g \geq 1.45$ "Excellent large effect" (Guler et al., 2022).

Research Results

Science Scientific Creativity

The pre-test scores of both groups were subject to an independent samples t-test analysis for the total score and all sub-dimensions (i.e. fluency, flexibility, originality) of scientific creativity skills (see Table 2).

Table 2
Scientific Creativity in Science Pre-Test Results

Sub-dimension	Group	*N*	*M*	*SD*	*SEM*	*F*	*t*	*df*	*p*	M_2-M_1	*SE*difference
Fluency	E	24	3.95	2.37	.48	0.090	0.739	44	.462	0.503	.681
	C	22	3.45	2,24	.47						
Flexibility	E	24	1.33	1.27	.26	0.801	0.665	44	.508	0.242	.364
	C	22	1.09	1.19	.25						
Originality	E	24	0.83	0.96	.20	0.233	0.601	44	.546	0.151	.252
	C	22	0.68	0.71	.15						
Total Score	E	24	6.13	4.06	.83	0.560	0.790	44	.434	0.897	1.143
	C	22	5.23	3.66	.77						

E= Experimental Group, C= Control Group, M= Mean, SD= Std. Deviation, SEM= Std. Error Mean, SEdifference= Std. Error Difference

As Table 2 reveals, there is no statistically significant difference between the pre-test scores of both groups in terms of all sub-dimensions of scientific creativity and total scores. As no significant difference was observed between the pre-tests, the pre- and post-test difference scores of both groups were exposed to an independent samples t-test (see Table 3).

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Table 3
Science Scientific Creativity Survey Difference Score Independent Samples T-Test Results

Sub-dimension	Group	*N*	*M*	*SD*	*SEM*	*F*	*t*	*df*	*p*	M_2-M_1	*SE*difference	Hedges' *g*
Fluency	E	24	2.83	1.46	.298	8.74	7.78	44	.005	2.651	.340	2.304
	C	22	0.18	0.66	.141							
Flexibility	E	24	2.50	0.93	.190	1.80	8.90	41	p < .001	2.136	.240	2.239
	C	22	0.36	0.65	.140							
Originality	E	24	2.54	1.25	.255	4.61	6.69	40	p < .001	2.132	.318	1.985
	C	22	0.40	0.85	.182							
Total Score	E	24	7.91	2.71	.554	10.81	11.09	31	p < .001	6.962	.627	3.283
	C	22	0.95	1.17	.250							

E= Experimental Group, C= Control Group, M= Mean, SD= Std. Deviation, SEM= Std. Error Mean, SEdifference= Std. Error Difference

As shown in Table 3, there is a significant difference in favor of the experimental group in the sub-dimensions of fluency, flexibility, originality, and total scores of scientific creativity. Additionally, the effect sizes (Hedges' g) of the differences between the pre- and post-test scores of the scientific creativity skill, including fluency, flexibility, originality, and total scores of both groups, were calculated to be 2.304, 2.239, 1.985, and 3.283, respectively. Thus, the differentiation observed for the experimental group in all sub-dimensions can be claimed to have a perfect large effect value (Hedges' g > 1.45).

Dependent samples t-test was performed to observe the differences in the pre- and post-test scores belonging to the experimental group and the control group (see Table 4).

Table 4
Pre-test and post-test results of the experimental group and control group with which the Science Scientific Creativity Questionnaire was applied.

Sub-dimension	Group	*N*	*M*	*SD*	*SEM*	*t*	*df*	*p*	M_2-M_1	Hedges' *g*
Fluency	E	24	2.83	1.464	.298	9.47	23	p < .001	2.833	1.911
	C	22	0.18	0.664	.141	1.28	21	.213	0.181	-
Flexibility	E	24	2.50	0.932	.190	13.13	23	p < .001	2.500	2.648
	C	22	0.36	0.657	.140	2.59	21	.017	0.363	0.546
Originality	E	24	2.54	1.250	.255	9.95	23	p < .001	2.541	2.007
	C	22	0.40	0.854	.182	2.24	21	.036	0.409	0.474
Total Score	E	24	7.91	2.717	.554	14.27	23	p < .001	7.916	2.877
	C	22	.954	1.174	.250	3.81	21	.001	.954	0.804

E= Experimental Group, C= Control Group, M= Mean, SD= Std. Deviation, SEM= Std. Error Mean

As Table 4 indicates, a significant difference was observed between the fluency, flexibility, originality, and total pre- and post-test scores belonging to the experimental group. The effect sizes of sub-dimensions of fluency, flexibility, originality and total scores belonging to the experimental group were determined to be 3.73, 5.17, 3.92, and 5.62, respectively, and these values fall within the perfectly large effect range (Hedges' g >1.45). No significant difference was observed in the sub-dimension of fluency between the pre- and post-test scores of the control group. However, a statistically significant difference was found in the flexibility, originality, and total pre- and post-test scores of the control group. For the control group, the effect sizes in sub-dimensions of flexibility and originality

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were 1.06 and .91, respectively. Both sub-dimensions fall within the large effect range (0.75 < Hedges' g < 1.09). The effect size of the total score is 1.56, which falls within the perfectly large effect range (Hedges' g > 1.45).

Reflective Thinking

The pre-test scores of both groups were subject to an independent samples t-test in terms of the total score and all sub-dimensions (i.e. understanding, reflection, critical reflection) of reflective thinking skills (see Table 5).

Table 5
Pre-test Results of Reflective Thinking Scale in Science

Sub-dimension	Group	*N*	*M*	*SD*	*SEM*	*F*	*t*	*df*	*p*	M_2-M_1	*SE*difference
Understanding	E	24	13.54	5.17	1.05	0.576	0.375	43	7.08	0.541	1.443
	C	22	13	4.55	.714						
Reflection	E	24	12.33	5.03	1.027	0.251	0.400	43	.690	0.560	1.402
	C	22	11.77	4.41	.941						
Critical Reflection	E	24	11.16	3.50	.713	0.083	0.492	43	.623	0.484	.985
	C	22	10.68	3.16	.672						
Total Score	E	24	37.04	12.83	2.620	0.835	0.447	44	.655	1.587	3.551
	C	22	35.45	11.07	2.361						

E= Experimental Group, C= Control Group, M= Mean, SD= Std. Deviation, SEM= Std. Error Mean, SEdifference= Std. Error Difference

As shown in Table 5, the pre-test scores of the two groups do not show a statistically significant variation across all sub-dimensions of reflective thinking and the total scores. Given that the pre-test scores did not differ significantly, an independent samples t-test was used to analyze the difference scores between the pre- and post-tests of the groups (see Table 6).

Table 6
Science Reflective Thinking Scale Difference Score Independent Samples T-Test Results

Sub-dimension	Group	*N*	*M*	*SD*	*SEM*	*F*	*t*	*df*	*p*	M_2-M_1	*SE*difference	Heges' *g*
Understanding	E	24	5.33	1.04	.214	0.673	13.40	44	p < .001	3.696	.275	4.17
	C	22	1.63	0.78	.168							
Reflection	E	24	4.50	2.02	.412	0.484	3.28	44	.002	1.727	.526	0.97
	C	22	2.77	1.47	.315							
Critical Reflection	E	24	3.16	1.78	.364	0.033	0.209	43	0.837	0.121	.580	
	C	22	3.04	2.14	.458							
Total Score	E	24	13	2.82	.577	0.367	6.174	41	p < .001	5.545	.898	1.82
	C	22	7.45	3.26	.695							

E= Experimental Group, C= Control Group, M= Mean, SD= Std. Deviation, SEM= Std. Error Mean, SEdifference= Std. Error Difference

As shown in Table 6, there exists a significant difference in the comprehension, reflection sub-dimensions, and total scores of reflective thinking for the benefit of the experimental group. However, any significant difference was not observed between the groups in the critical reflection sub-dimension (p > 0.05). Moreover, the effect

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sizes (Hedges' g) with regard to the differences observed between the pre- and post-test scores that belong to the sub-dimension of the scientific creativity skill comprehension, reflection, and total scores of both groups were calculated to be 4.17, .97, 1.82, respectively. In this regard, the difference in the comprehension sub-dimension and total scores of the reflective thinking of the experimental group in comparison to other group can be claimed to have an excellent large effect value (Hedges' g > 1.45), whereas the reflection sub-dimension has a low effect (Hedges' g > 1.10).

Dependent samples t-test was carried out in order to examine the differences in the pre- and post-test scores of the experimental group and control group (see Table 7).

Table 7
Pre- and Post-Test Results of the Experimental and Control Groups with which the Reflective Thinking Scale was Applied

Sub-dimension	Group	*N*	*M*	*SD*	*SEM*	*t*	*df*	*p*	M_2-M_1	Hedges' g
Understanding	E	24	5.33	1.04	0.214	24.89	23	P< 0.05	5.33	5.590
	C	22	1.63	0.78	0.168	9.72	21	P< 0.05	1.63	2.068
Reflection	E	24	4.50	2.02	0.412	10.90	23	P< 0.05	4.50	2.199
	C	22	2.77	1.47	0.315	8.80	21	P< 0.05	2.77	1.864
Critical Reflection	E	24	3.16	1.78	0.364	8.68	23	P< 0.05	3.16	1.753
	C	22	3.04	2.14	0.458	6.64	21	P< 0.05	3.04	1.540
Total Score	E	24	13	2.82	0.577	22.51	23	P< 0.05	13	4.551
	C	22	7.45	3.26	0.695	10.71	21	P< 0.05	7.45	2.261

E= Experimental Group, C= Control Group, M= Mean, SD= Std. Deviation, SEM= Std. Error Mean

As presented in Table 7, a significant difference was realized between the sub-dimensions of comprehension, reflection, critical reflection, and total pre- and post-test scores of the experimental group. Additionally, a significant difference was found between the comprehension, reflection, critical reflection, and total pre- and post-test scores that belonged to the control group. The effect size values of all sub-dimensions and total scores which belonged to both groups were examined, and all of them were found to fall within the perfect large effect (Hedges'g > 1.45).

Discussion

A statistically significant difference was observed between the post-test scores of both groups, which seemed to the benefit of the experimental group with regard to fluency, flexibility, originality, and total score of scientific creativity, and this difference had an excellent large effect value. This difference between the experimental group and the control group is thought to result from the content of scenario-based learning activities. As many research problems are created from the scenarios by students, different suggestions for solutions are offered for those selected to be solved, which is thought to be related directly to the fluency and flexibility sub-dimensions of scientific creativity (Hu & Adey, 2002; Kaya, 2010). Furthermore, the fluency sub-dimension is intertwined with flexibility, which can be expressed as producing a large number of ideas about a topic or as generating a large number of ideas in different categories (Hu & Adey, 2002; Torrance, 1990). What is more, the discussion and peer persuasion in the scenario implementation stages may also have caused this difference in the fluency and flexibility sub-dimensions (Cremin et al., 2015; Hu & Adey, 2002; Powers, 2015). The difference in the originality sub-dimension is thought to stem from the fact that students propose solutions to the problems they pose, conduct research on these solutions they suggest, and present their results to their peers, since students were guided only by clues and were left as free as possible. The lack of restrictions on students is considered to cause this difference in originality scores (Hu & Adey, 2002). The post-test scores belonging to the experimental group showed statistically significant difference in comparison to the pre-test in terms of fluency, flexibility, originality, and total scores, and that differentiation had an excellent large effect value for all sub-dimensions. In the control group, a significant difference was realized in the post-test scores when they were compared to the pre-test scores in terms of flexibility, originality,

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and total score. This difference was found to be in the range of a large effect in the flexibility and originality sub-dimension and to have a perfectly large effect on the total score. This difference, which emerged in terms of all sub-dimensions of scientific creativity and the total score in the experimental group, is thought to result from the content of scenario-based activities, posing scenario-related problems, offering numerous solution suggestions, researching from sources chosen by the student, persuading his peers for his solution in case of disagreement, and discussions throughout the process. This is because the activities in which students can put forward many ideas are very limited in these textbooks. The difference in terms of flexibility, originality, and total score may stem from the smart board activities used because the activities in question often include activities that aim at the flexibility sub-dimension such as categorization and design activities (such as preparing a plate that complies with healthy eating rules with a large variety of food). The difference in the originality sub-dimension in both groups may also be related to the number of students in the groups, which stems from the fact that the originality score of the ideas increases as the number of individuals decreases (Hu & Adey, 2002).

The comprehension and reflection sub-dimensions and total scores of the reflective thinking skill differ statistically significantly favoring the experimental group, and this differentiation has a perfectly large effect on the comprehension sub-dimension and total scores and a low effect value on the critical reflection dimension. This finding is consistent with Gulmez-Gungormez et al. (2016)'s study. Hence, it is thought that this difference is likely to stem from the fact that the scenarios include daily life situations, students manage the research process through collaborative discussions, and experience processes such as peer persuasion (Rogers, 2002; Taggart & Wilson, 2005; Ünver, 2003). In addition, problem-posing tasks may have supported the comprehension and reflection sub-dimensions of reflective thinking (Haigh, 2000). It can be said that the reflective thinking skill, especially at the peer persuasion stage, is closely related to the reflection and critical reflection sub-dimensions as students try to change their peers' minds by using their prior knowledge and the data they obtained from the research. Because this situation includes the evaluation of the advantages and disadvantages of ideas, it may cause differences in the reflection and critical reflection dimensions of reflective thinking (Huges et al., 1997; Rogers, 2002). The post-test scores that belonged to the experimental group and the control group were realized to differ statistically significantly compared to the pre-test scores in terms of all sub-dimensions of reflective thinking (understanding, reflection, critical reflection) and the total score. It was observed that this differentiation had an excellent large effect value for both groups and all sub-dimensions, which may have resulted from activities such as posing problems, offering solution suggestions, conducting research, group discussions about solution suggestions and research, and peer persuasion in the scenarios for the experimental group (Errington, 2011; Huges et al., 1997). The difference in the control group, nevertheless, may stem from the activities in the textbooks and smart board activities, as the subject was covered with the activities in the textbook and reinforced in the classroom through smart board activities. The content of the activities in the textbook often includes discussion sections and areas in which students can write their ideas and opinions, which may have enabled students an opportunity to understand the subject in depth and develop reflective thinking with all its sub-dimensions (Rogers, 2002; Tao & Zhang, 2018).

Conclusions and Implications

In the current study, which examined the impacts of scenario-based science activities on the scientific creativity and reflective thinking skills of fourth-grade students studying in primary school, the science lesson was taught via ten weeks of scenario-based science activities in the experimental group, and by using the activities in the textbook and smart board activities in the control group. This situation constitutes the limitation of the current study.

The present study, which benefited from the science scientific creativity survey and the science reflective thinking scale as data collection tools, indicated a statistically significant difference between the scientific creativity pre- and post-test total scores belonging to the experimental group and their scores on all sub-dimensions (fluency, flexibility, originality). Furthermore, the experimental group displayed statistically significant differences from the control group across all sub-dimensions of scientific creativity. Additionally, the control group's post-test scores differed significantly from their pre-test scores in terms of flexibility, originality, and total score.

The reflective thinking skill was observed to differ statistically significantly favoring the experimental group with regard to understanding and reflection sub-dimensions and total scores. Furthermore, the experimental group demonstrated statistically significant differences between their post-test and pre-test scores across all sub-dimensions of reflective thinking, as well as the total score. Similarly, the control group's post-test scores differed statistically significantly from their pre-test scores in all sub-dimensions of reflective thinking and the overall score.

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These findings suggest that scenario-based science activities developed scientific creativity in all its sub-dimensions more than the method practiced in the control group. Furthermore, scenario-based learning activities were found to improve the reflective thinking skill in all its sub-dimensions (understanding, reflection, critical reflection), and the comprehension and reflection sub-dimensions of reflective thinking were realized to improve more in the experimental group in comparison to the method practiced in the control group.

The results suggest that students are provided more space in science lessons for problem posing, offering solution proposals, peer persuasion, and research activities, which are included in scenario-based learning activities because they develop reflective and creative thinking skills. At the primary school level, it is recommended to teach with scenario examples, especially those that consist of fictional characters but contain real-life situations. Moreover, more studies are recommended to be conducted on scenario-based science activities, and more examples should be created so that teachers can benefit from them in lessons and researchers can utilize them in their studies. In future studies, the relationship between the level of problem-posing and scientific creativity skills can be examined, as well.

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Tekin Guler

Assistant Professor, Department of Child Development, Cekerek Fuat Oktay Vocational School of Health Services, Yozgat Bozok University, Cekerek, Yozgat, Türkiye.
E-mail: tekinguler88@gmail.com
ORCID: https://orcid.org/0000-0003-4300-2228